

What is claimed is:

1. A method for forming interconnects, comprising:  
providing a substrate having fine recesses formed in a  
5 surface thereof;

plating the surface of the substrate in a plating liquid;  
and  
electrolytic etching the plated film formed on the  
surface of the substrate in an etching liquid.

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2. The method according to claim 1, wherein the etching liquid contains at least one additive selected from the group consisting of an additive which forms a complex compound or an organic complex with the metal of the plated film and an additive which can lower the corrosion potential of the metal of the plated film.

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20 3. The method according to claim 1, wherein a waveform of current flowing in said electrolytic etching is a pulse waveform or a PR pulse waveform.

4. An apparatus for forming interconnects, comprising:  
a plating section for holding a plating liquid and plating a surface of a substrate having fine recesses formed in the surface thereof in the plating liquid; and  
25 an etching section for holding an etching liquid and electrolytic etching the plated film formed on the surface of the substrate.

5. The apparatus according to claim 4, wherein said etching section includes:

5      a substrate holder for holding a substrate with its surface downward;

    a cathode plate immersed in said etching liquid and located facing the lower surface of the substrate held by said substrate holder; and

10     a relative movement mechanism for allowing the substrate held by said substrate holder and said cathode plate to move relatively.

6. The apparatus according to claim 5, further comprising:

15     a plurality of grooves extending over the full length of said cathode plate in the surface thereof; and

    a plurality of etching liquid feed holes formed in said cathode plate for feeding the etching liquid to said grooves, said plurality of etching liquid feed holes communicating with 20     said grooves.

7. The apparatus according to claim 5, wherein said relative movement mechanism comprises a substrate-rotating mechanism for rotating the substrate and a cathode plate-moving mechanism for rotating, reciprocating, eccentrically rotating said cathode plate, or making a scroll motion of said cathode plate.

8. The apparatus according to claim 7, further comprising;

a plurality of grooves extending over the full length of said cathode plate in the surface thereof; and

5 a plurality of etching liquid feed holes formed in said cathode plate for feeding the etching liquid to said grooves, said plurality of etching liquid feed holes communicating with said grooves.

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9. The apparatus according to claim 5, wherein said substrate holder is constructed to hold the substrate in a vacuum attraction manner or in an electrostatic chucking manner.

15 10. The apparatus according to claim 6, wherein said substrate holder is constructed to hold the substrate in a vacuum attraction manner or in an electrostatic chucking manner.

20 11. The apparatus according to claim 7, wherein said substrate holder is constructed to hold the substrate in a vacuum attraction manner or in an electrostatic chucking manner.

25 12. The apparatus according to claim 5, wherein said cathode plate is composed of a material having a poor adhesion to copper.

13. An apparatus for forming interconnects by forming a copper film on a surface of a substrate to fill copper into fine recesses formed in the surface of the substrate, comprising:

5           a housing;  
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a transport route provided in said housing for transporting the substrate; and  
a copper-plating section, an electrolytic or chemical polishing section, and an annealing section which are disposed  
10           along said transport route.

14. The apparatus according to claim 13, further comprising a cleaning section provided in said housing for cleaning the substrate.

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15. The apparatus according to claim 13, wherein at least two of said electrolytic or chemical polishing sections are provided for carrying out a first-stage electrolytic or chemical polishing and a second-stage electrolytic or chemical  
20           polishing.

16. The apparatus according to claim 14, wherein at least two of said electrolytic or chemical polishing sections are provided for carrying out a first-stage electrolytic or  
25           chemical polishing and a second-stage electrolytic or chemical polishing.

17. The apparatus according to claim 13, wherein said electrolytic or chemical polishing section includes:

a substrate holder for holding a substrate with its surface downward;

5 a cathode plate immersed in a polishing liquid and located facing the lower surface of the substrate held by said substrate holder; and

10 a relative movement mechanism for allowing the substrate held by said substrate holder and said cathode plate to move relatively.

18. The apparatus according to claim 14, further comprising:

15 a plurality of grooves extending over the full length of said cathode plate in the surface thereof; and

a plurality of polishing liquid feed holes formed in said cathode plate for feeding the polishing liquid to said grooves, said plurality of polishing liquid feed holes communicating with said grooves.

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19. The apparatus according to claim 14, wherein said relative movement mechanism comprises a substrate-rotating mechanism for rotating the substrate and a cathode plate-moving mechanism for rotating, reciprocating, eccentrically rotating said cathode plate, or making a scroll motion of said cathode plate.

20. The apparatus according to claim 19, further comprising:

a plurality of grooves extending over the full length of said cathode plate in the surface thereof; and

5 a plurality of polishing liquid feed holes formed in said cathode plate for feeding the polishing liquid to said grooves, said plurality of polishing liquid feed holes communicating with said grooves.

10 21. The apparatus according to claim 17, wherein said substrate holder is constructed to hold the substrate in a vacuum attraction manner or in an electrostatic chucking manner.

15 22. The apparatus according to claim 17, wherein said cathode plate is composed of a material having a poor adhesion to copper.

23. The apparatus according to claim 13, further  
20 comprising a cap-plating treatment section for forming a protective film which selectively covers and protects the exposed surface of copper interconnects.

24. The apparatus according to claim 23, wherein said  
25 cap-plating treatment section includes a Pd-attaching treatment section and an electroless CoWP-plating section.

25. A method for forming interconnects by forming a copper film on a surface of a substrate to fill copper into fine recesses formed in the surface of the substrate, comprising:

5 plating the substrate with copper to form the copper film on the surface and to fill copper into the fine recesses of the substrate;

10 *W* electrolytic or chemical polishing the surface of the substrate having the copper film thereon in a polishing liquid; and

annealing the substrate in such a state that the copper film remains on the entire surface of the substrate, after said polishing.

15 26. The method according to claim 25, further comprising applying a CMP process to the surface of the substrate, after said annealing.

27. The method according to claim 26, further comprising applying a cap-plating treatment to the substrate to selectively cover the exposed surface of the copper interconnects with a protective film, after said CMP process.

28. A method for forming interconnects by forming a copper film on a surface of a substrate to fill copper into fine recesses formed in the surface of the substrate, comprising:

plating the substrate with copper to form the copper film on the surface and to fill copper into the fine recesses of the substrate;

annealing the substrate having the copper film thereon;

5 and

electrolytic or chemical polishing the surface of the substrate in a polishing liquid, after said annealing.

29. The method according to claim 28, further comprising  
10 applying a cap-plating treatment to the substrate to selectively cover the exposed surface of the copper interconnects with a protective film, after said polishing.

30. A polishing liquid for use in electrolytic or  
15 chemical polishing of copper by immersing therein a substrate having fine recesses in a surface thereof which are filled with copper by forming copper film, comprising:

at least one inorganic acid and/or an organic acid capable of dissolving copper; and

20 at least one viscosity-increasing agent selected from the group consisting of polyhydric alcohols, high-molecular weight polyhydric alcohols and alkylene glycol alkyl or aryl ethers.

31. The polishing liquid according to claim 30, further  
25 comprising an additive which can adhere to the surface of copper and electrically and/or chemically suppress the dissolution of copper.

32. The polishing liquid according to claim 30, further comprising a basic liquid or an additive which forms a strong complex with copper or promotes the formation of a passivated film on the surface of copper.

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33. The polishing liquid according to claim 30, having a viscosity of 10 cP (0.1 Pa · s) or more and a conductivity of 20 mS/cm or lower.

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34. The polishing liquid according to claim 33, further comprising an additive which can adhere to the surface of copper and electrically and/or chemically suppress the dissolution of copper.

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35. The polishing liquid according to claim 33, further comprising a basic liquid or an additive which forms a strong complex with copper or promotes the formation of a passivated film on the surface of copper.

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36. A method for polishing a substrate having fine recesses in a surface thereof which are filled with copper by forming copper film, comprising:

electrolytic or chemical polishing the surface of the substrate, where only copper is exposed thereon, in a polishing liquid in which the dissolution of copper is suppressed; and

electrolytic or chemical polishing the surface of the substrate, where only copper is exposed, or copper and a

conductive material other than copper are exposed, in a polishing liquid in which the dissolution of copper is further suppressed.

5 37. The method according to claim 36, wherein copper remaining on the surface of said other conductive material is removed by electrolytic or chemical polishing.

10 38. The method according to claim 36, wherein said other conductive material remaining on the surface of the substrate is removed.

15 39. The method according to claim 38, wherein said copper and/or said other conductive material remaining on the surface of the substrate is removed either by passivating only the surface of said copper and preferentially electrolytic or chemical polishing said other conductive material, or by passivating the entire surface including said copper and said other conductive material, and composite electrolytic 20 polishing said entire surface.

40. An apparatus for forming interconnects by forming a copper film on a surface of a substrate to fill copper into fine recesses formed in the surface of the substrate, 25 comprising:

a loading/unloading section;

a copper-plating section;

an electrolytic or chemical polishing section; and

a transporting device for transporting the substrate.

41. An apparatus for forming interconnects by forming a copper film on a surface of a substrate to fill copper into 5 fine recesses formed in the surface of the substrate, comprising:

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a loading/unloading section;  
10 an annealing section; and  
a transporting device for transporting the substrate.

42. An apparatus for forming interconnects by forming a copper film on a surface of a substrate to fill copper into 15 fine recesses formed in the surface of the substrate, comprising:

20 a loading/unloading section;  
a copper-plating section;  
an electrolytic or chemical polishing section;  
an annealing section;  
a cleaning section; and  
a transporting device for transporting the substrate.

43. An apparatus for forming interconnects by forming a copper film on a surface of a substrate to fill copper into 25 fine recesses formed in the surface of the substrate, comprising:

a loading/unloading section;

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a copper-plating section;  
an electrolytic or chemical polishing section;  
an annealing section;  
a cleaning section;  
5 a chemical mechanical polishing section; and  
a transporting device for transporting the substrate.

44. An apparatus for forming interconnects by forming a copper film on a surface of a substrate to fill copper into  
10 fine recesses formed in the surface of the substrate,  
comprising:

a loading/unloading section;  
a copper-plating section;  
an electrolytic or chemical polishing section;  
15 an annealing section;  
a cap-plating treatment section; and  
a transporting device for transporting the substrate.

45. The apparatus according to claim 42, wherein said  
20 cleaning section also carries out drying of the substrate.

46. The apparatus according to claim 43, wherein said  
cleaning section also carries out drying of the substrate.

25 47. An apparatus for forming interconnects by forming a copper film on a surface of a substrate to fill copper into fine recesses formed in the surface of the substrate,  
comprising:

- 5 a loading/unloading section;
- a copper-plating section;
- a first electrolytic or chemical polishing section;
- a second electrolytic or chemical polishing section;
- an annealing section; and
- a transporting device for transporting the substrate.

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